

CONSERVATION PRACTICE STANDARD

LAND RECLAMATION, LANDSLIDE TREATMENT

(No. and Ac.)

CODE 453

DEFINITION

Managing in-place natural materials, mine spoil (excavated over-burden), mine waste or overburden to reduce down-slope movement.

PURPOSE

- Repair unstable slopes caused by slope failure, and reduce the likelihood of enlargement or renewed movement of slope surfaces;
- Regrade and/or reconfigure slopes that have a potential of becoming unstable.
- Protect public health, safety, property, and general welfare;
- Prevent excessive erosion and sedimentation;
- Improve water quality and landscape resource quality; and
- Create a manageable condition directing towards establishing surface protection and beneficial land use.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to the reclamation of areas where in-place material, mine spoil or waste, or rock cut road banks are unstable, moving, or judged to have potential of moving down slope in a manner that will cause damage to public health, property, or the environment. It does not apply to constructed embankment surfaces such as road fills, dams, dikes, levees and terraces.

CRITERIA

General Criteria Applicable to All Purposes

Reconstruction plans must comply with all local, state, and federal laws and regulations relating to reclamation.

Land reclamation on landslide sites shall include the components necessary to reshape, regrade, and stabilize the unstable area; to prevent future degradation of water, public health and safety, property, and to improve the overall use of the land.

Investigations. Investigations shall include and extend beyond the area of the landslide and shall be made to determine:

1. The extent of the problem or potential problem area,
2. Surface profiles, cross sections, and topographic features,
3. Geologic profiles and cross sections showing stability and conditions of strata and details of the slip zone,
4. Soil classification and properties, including gradation, density, strength, and chemical characteristics,
5. Ground-water conditions,
6. Depth extent, and volume of material involved,
7. Estimated pre-slide profile and subsurface conditions,
8. Conditions where slopes are stable in similar materials, and
9. Extrinsic factors (e.g. land use activities and/or precipitation events) that triggered or remobilized the failure.

Extreme caution must be exercised and careful planning is required before permitting any personnel, drilling equipment, or construction machinery, in the slide area. A slide is often active during wet periods and may be comparatively stable during dry periods.

Slope stability. Measures developed to prevent or stabilize slides shall be based on engineering analysis and judgment made by an engineer trained and experienced in soil mechanics and soil bioengineering.

Slope stability analysis shall account for all critical soil and loading conditions. The strength parameters of natural soil and rock or of waste materials shall be based on the appropriate conditions for each slide. Long-term strength parameters ($c=0$ and internal friction based on residual shear) shall be used. The methods of slope stability analysis are to be appropriate for the loading conditions and for the location and shape of sliding or potential failure surfaces.

Appropriate safety factors shall be provided based on the degree of uncertainty in the soil strength values used, the soil and water conditions assumed, and the detail of the analysis used.

When there is a potential for loss of life or damage to farmsteads, residential areas, frequently traveled roads, occupied facilities, or important public utilities, the measures shall include removal of the material subject to sliding or any other control to ensure safety.

The requirements contained in the NRCS National Engineering Manual Part 531.26 (a) shall apply for the geologic investigations and seismic assessments. Criteria for minimum seismic coefficients and recurrence interval shall be as required in the state building code.

Water control. Sources of water that would enter the landslide area or contribute to instability shall be controlled to the extent possible in accordance with the following:

- **Surface runoff water.** Runoff water that would enter the landslide area is to be intercepted and conveyed to a stable outlet.
- **Water from direct precipitation.** Infiltration shall be limited to the extent

possible by providing positive surface drainage and sealing surface cracks within the area. Grading and shaping may be required to provide positive surface drainage. Terraces (600), grade stabilization structures (410), and lined waterways (468) are to be installed as needed to provide safe water disposal without erosion. Where permissible, all means of water control shall be installed with a positive grade to reduce seepage. The surface of the treated area shall be protected from erosion as appropriate.

- **Ground water.** Design measures, including vegetative treatment where appropriate, shall be taken to intercept ground water that contributes to instability of the area. Drainage systems shall be designed in accordance with Part 633, Chapter 26 of the National Engineering Handbook, and the system shall be designed to remain operational in the event of limited movement of the area after construction.

Earth material control. The design shall take into consideration the following factors on impacting loading, strength or counter-buttressing as appropriate:

- earth material
- internal water
- rock material
- **Loading control.** Where appropriate, consider alternatives for loading control, including: removing excess material from the upper portions of the slide mass; removing the entire slide mass; dewatering at least the upper portion of the slide, and removing excess weight associated with development. Sites for safe disposal of excavated slide material should be identified as part of planning and design.
- **Slope reduction.** Critical slopes within the slide area shall be reduced by grading when practical.
- **Increasing internal strength.** The design shall analyze the impact of removing and recompacting of material at designed levels of moisture and compactive effort.

It shall also analyze the impact of biotechnical slope stabilization practices.

- **External restraints.** External restraints shall be used where slope movements must be limited due to high-valued improvements, and where manipulation of the earthen material may not achieve the desired results. External restraints shall be designed to withstand overturning, sliding at or below the base, and bearing failure of the foundation. All measures shall include provisions for proper drainage.

Vegetative treatment. Vegetation shall be planted using selected soil bioengineering or biotechnical slope stabilization techniques appropriate to the site. Deep rooted grasses and shrubs with proven performance in soil bioengineering applications shall be used. The transpiration potential and rooting depth of the vegetation applied shall be considered. Site conditions including soil pH, particle size, and nutrient content shall be analyzed, and this information used to select the appropriate vegetative treatment and plant materials for the site.

Where needed and/or permitted, apply soil amendments and plant nutrients to achieve the physical or chemical soil conditions suitable to support vegetative growth. Such amendments may include manure, compost, or mulch.

All seeding shall be in accordance with the Critical Area Planting standard and specifications (342).

Component practices. All individual practices installed as a component of landslide treatment are to be designed and installed in accordance with applicable NRCS conservation practice standards and specifications. If NRCS standards are not available, the practice is to be designed and installed using current engineering technology.

Environmental. All disturbed areas are to be provided with adequate water disposal systems and established with vegetative cover, or otherwise protected, to control erosion and sediment as soon as practicable. Temporary protective measures will be necessary if a long delay is anticipated in establishing permanent cover. Human, animal and vehicular traffic is to be controlled to protect the area.

CONSIDERATIONS

Consider offsite water quality effects such as acid mine drainage.

Consider designing drainage systems that remain operative after limited movement. Pipes should be used with caution because of the potential of breaking and/or misalignment with further movement. Flat or nearly flat gradients should be avoided for the same reasons.

Consider visual resources with other design features during planning, design, and installation. All disturbed areas can be reshaped and regraded to blend in with the surrounding land features.

Consider the need for access roads that would facilitate final reclamation activities and operation and maintenance.

PLANS AND SPECIFICATIONS

Plans and specifications for slide treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

A reclamation plan must be developed for each site.

OPERATION AND MAINTENANCE

An O&M plan shall be prepared that provides specific details concerning operation and maintenance of conservation practices identified in the reclamation plan. The operation and maintenance plan shall specify procedures for:

- Promptly repairing and revegetating bare spots, eroded areas, areas of excessive settlement, and other areas on which the initial attempt to establish vegetation was not successful.
- Adding soil amendments to soils that cannot support adequate vegetation or replacing them with suitable soil material.
- Keeping drainage structures and channels clean and functional.
- Maintaining access roads.
- Applying fertilizer and lime.

REFERENCES

Landslides: Investigation and Mitigation.

Special Report 247. 1996. Transportation

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National Academy Press, Washington, D.C.,
673 p.

National Engineering Handbook. Chapters 16,
18, 26. USDA-NRCS.

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Handbook. USDA-NRCS.